EXHIBIT D

TO THE DECLARATION OF ARPITA BHATTACHARYYA IN SUPPORT OF ASETEK DANMARK A/S'S MOTION FOR PARTIAL SUMMARY JUDGMENT

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
60/954,987	08/09/2007		200	47621-65		

CONFIRMATION NO. 3611

FILING RECEIPT

23971
BENNETT JONES
C/O MS ROSEANN CALDWELL
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CANADA

Date Mailed: 08/21/2007

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Applicant(s)

GEOFF SEAN LYON, Calgary, CANADA;

Power of Attorney: The patent practitioners associated with Customer Number 23971

If Required, Foreign Filing License Granted: 08/20/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US60/954,987**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

FLUID HEAT EXCHANGER

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PTO/SB/14 (06-07)
Approved for use through 06/30/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	47621-65
	Application Number	

Title of Invention	FLUID HEAT EXCHANGER

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

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☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ◯ Legal Representative under 35 U.S.C. 117 ◯ Party of Interest under 35 U.S.C. 118

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	GEOFF	SEAN	LYON	

Residence Information (Select One) ◯ US Residency ◉ Non US Residency ◯ Active US Military Service

City	Calgary	**Country Of Residence** i	CA
Citizenship under 37 CFR 1.41(b) i	CA		

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Address 2			
City	Calgary	**State/Province**	AB
Postal Code	T1Y 6B6	**Country** i	CA

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	23971
Email Address	caldwellr@bennettjones.ca

Add Email Remove Email

Application Information:

Title of the Invention	FLUID HEAT EXCHANGER		
Attorney Docket Number	47621-65	**Small Entity Status Claimed**	☐
Application Type	Provisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	2	**Suggested Figure for Publication (if any)**	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	47621-65
	Application Number	

Title of Invention	FLUID HEAT EXCHANGER

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S. C. 122(b) and certify that the invention disclosed in the attached application has not been and will not be the subject of an application filed in another country, or under a multilateral agreement, that requires publication at eighteen months after filing.

Representative Information:

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Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ US Representative (37 CFR 11.9)
Customer Number	23971		

Domestic Priority Information:

This section allows for the applicant to claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c). Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)

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Remove

Application Number	Country i	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			◉ Yes ○ No

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Assignee 1 Remove

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	47621-65
	Application Number	

Title of Invention	FLUID HEAT EXCHANGER

If the Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
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Email Address			

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Signature:

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Signature	/Roseann B. Caldwell/			Date (YYYY-MM-DD)	2007-08-09
First Name	Roseann	Last Name	Caldwell	Registration Number	37077

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Fluid Heat Exchanger

Background

Fluid heat exchangers are used to cool electronic devices by accepting and dissipating thermal energy therefrom.

Brief Description of the Drawings

Referring to the drawings wherein like reference numerals indicate similar parts throughout the several views, several aspects of the present invention are illustrated by way of example, and not by way of limitation, in detail in the figures, wherein:

Figure 1 is a top plan view of a fluid heat exchanger according to one embodiment of the invention, with the top cap cut away to facilitate viewing internal components;

Figure 2 is a sectional view along line I-I of Figure 1;

Figure 3 is a sectional view along line II-II of Figure 2;

Figure 4 is an exploded, perspective view of a fluid heat exchanger according to another embodiment of the invention; and

Figure 5 is a top plan view of the fluid heat exchanger of Figure 4 assembled with its top cap removed.

Description of Various Embodiments

The detailed description set forth below in connection with the appended drawings is intended as a description of various embodiments of the present invention and is not intended to represent the only embodiments contemplated by the inventor. The detailed description includes specific details for the purpose of providing a comprehensive understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without these specific details.

With reference to Figures 1 to 3, a fluid heat exchanger 100 is shown. Fluid heat exchanger is a heat exchanger which includes a heat spreader plate 102, an arrangement of microporous fluid channels 103, a fluid inlet passage 104, and a fluid outlet passage 106. A housing 109 operates with heat spreader plate 102 to form an outer limit of the heat sink and to define fluid flow passages 104, 106.

As shown in Figures 2 and 3, in use, the heat exchanger 100 is coupled to a heat source 107, such as an electronic device, including, but not limited to a microchip and integrated circuit. The heat exchanger may be thermally coupled to the heat source by a thermal interface material disposed therebetween, by coupling directly to the surface of the heat source, or by integrally forming the heat source and at least the heat spreader plate 102 of the fluid heat exchanger. The heat exchanger 100 may take various forms and shapes, but heat spreader plate 102 is formed to accept thermal energy from heat source 107. In the illustrated embodiment, heat spreader plate 102 includes a protrusion 102b that controls the positioning of the heat spreader plate relative to the heat source. Heat spreader plate 102 may include a portion of more conductive material to facilitate and control heat transfer, if desired.

Microporous fluid channels 103 are formed to accept the flow of heat exchanging fluid for thermal pick up and dissipation of heat passing through heat spreader plate 102. In the illustrated embodiment, microporous fluid channels 103 are defined by walls 110 that are thermally coupled to the heat spreader plate to accept thermal energy therefrom. For example, heat spreader plate 102 may include an upper surface 102a and a plurality of microchannel walls 110 may extend upwardly therefrom, whereby the area in between upper surface 102a and the microchannel walls 110 channels or directs fluid along a fluid flow path. The surfaces of upper surface 102a and walls 110 have a high thermal conductivity to allow sufficient heat transfer from the heat source 107 to fluid passing through channels 103. The surfaces forming channels 103 may be flat, formed with a porous structure, such as of sintered metal and/or silicon foam or roughened, for example, including troughs and/or crests designed to collect or repel fluid from a particular location. The microchannel walls 110 may be configured in a parallel configuration, as shown, or otherwise provided fluid can flow between the microchannel walls 110 along a fluid path. It is apparent to one skilled in the art that the microchannel walls 110 may be alternatively configured in any other appropriate configuration depending on various factors of desired flow,

thermal exchange, etc. For instance, grooves may be formed between sections of microchannel walls 110. Generally, microchannel walls 110 may desirably have dimensions and properties which seek to reduce or possibly minimize the pressure drop or differential of fluid flowing through the channels defined therebetween.

The microchannel walls 110 allow the fluid to undergo thermal exchange of thermal energy from the heat spreader plate to cool the heat source coupled to the heat spreader plate. As will be appreciated, some regions of the heat spreader plate may be exposed to greater inputs of thermal energy than other regions on that plate by nature of the components coupled directly thereto. In such a way, hot spot regions will be formed on the heat spreader plate and on the microchannel walls 110 in that region. The microchannel walls 110 may have a width dimension within the range of 20 microns -1 millimeter and a height dimension within the range of 100 microns to five millimeters, depending on the power of the heat source 107, desired cooling effect, etc. The microchannel walls 110 may have a length dimension which ranges between 100 microns and several centimeters, depending on the dimensions of the heat source, as well as the size of the hot spots and the heat flux density from the heat source. Alternatively, any other microchannel wall dimensions are contemplated. The microchannel walls 110 may be spaced apart by a separation dimension range of 20 microns -1 millimeter, depending on the power of the heat source 99, although any other separation dimension range is contemplated.

Other microporous channel configurations may be used alternatively to or together with microchannels, such as for example, a series of pillars, fins, or undulations, etc. which extend upwards from the heat spreader plate upper surface or tortuous channels as formed by a foam or sintered surface.

Fluid heat exchanger 100 further includes a fluid inlet passage 104, which in the illustrated embodiment includes a port 111 through the housing opening to a header 112 and thereafter a fluid inlet opening 114 to the microporous fluid channels 103.

The port and the header can be formed in various ways and configurations. For example, port 111 may be positioned on top, as shown, side or end regions of the heat exchanger, as desired. Port 111 and header 112 are generally of a larger cross sectional area than openings 114, so that a mass flow of fluid can be communicated substantially without restriction to openings 114.

Although only a single fluid inlet opening 114 is shown, there may be one or more fluid inlet openings providing communication from the header to the fluid channels.

Fluid inlet openings 114 may open to microchannels 103 opposite the heat spreader plate such that fluid passing through the opening may pass between walls 110 toward surface 102a, before being diverted along the axial length of the channels, which extend parallel to axis x. Since most installations will position the heat spreader plate as the lowermost, as determined by gravity, component of heat exchanger 100, the fluid inlet openings 114 will generally be positioned above the microchannels 103 such that fluid may flow through opening 114 down into the channels and then change direction to pass along their length.

Fluid inlet openings 114 may be positioned with respect to known hot spot regions to introduce fresh heat exchanging fluid directly to the hottest regions of the heat exchanger, as determined by the characteristics of the heat source 107 and its position relative to heat plate 102. The arrangement as well as the dimensions of openings 114 may be determined in light of the hot spots in plate 102 that are desired to be cooled. The locations of the hot spots as well as the amount of heat produced near or at each hot spot may be used to configure the heat exchanger such that openings 114 are placed above or proximal to the hot spot regions in the heat plate and therefore the channels 103. The delivery of fresh fluid first to the hot spot regions seeks to create a uniform temperature at the hot spot regions as well as areas in the heat source adjacent to the heat exchanger hot spot regions.

For example, fluid inlet openings 114 may open along the length of a microchannel between its ends, rather than introducing fluid to one end of a channel and allowing it to flow therealong. In the illustrated embodiment, heat exchanger 100 is intended to be mounted with heat source 107 generally centrally positioned relative to the perimeter edges of heat spreader plate 102. As such, in the illustrated embodiment, opening 114 is positioned generally centrally relative to the edges of the heat plate 102. Since the channels, in the illustrated embodiment extend substantially along the length of the heat plate between opposing sides thereof, opening 114 opens generally centrally between ends 103a of each channel. For example, opening 114 may be positioned in the middle 50% of the heat exchanger or possibly the middle 20% of the heat exchanger. The delivery of fresh fluid to the central hot spot region first before passing through

the remaining lengths of channels seeks to create a uniform temperature at the hot spot region as well as areas in the heat source adjacent to the heat exchanger hot spot region and reduces the pressure drop of fluid passing along the channels over that pressure drop that would be created if the fluid passed along the entire length of each channel.

Opening 114 may extend over any channel 103 through which it is desired that heat exchange fluid flows. Openings 114 may take various forms including, for example, various shapes, various widths, straight or curved edges (in plane or in section) to provide fluid flow features, open area, etc. as desired.

Heat exchanger 100 further includes a fluid outlet passage 106, which in the illustrated embodiment includes one or more fluid outlet openings 124 from the microporous fluid channels 103, a header 126 and an outlet port 128 opening from the housing. Although two fluid outlet openings 124 are shown, there may be one or more fluid outlet openings providing communication to the header from the fluid channels 103.

The port and the header can be formed in various ways and configurations. For example, port 128 may be positioned on top, as shown, side or end regions of the heat exchanger, as desired.

Fluid outlet openings 124 may be positioned at the end of microchannels 103 or, as shown, may create an opening opposite heat spreader plate 102 such that fluid passing through the channels pass axially along the length of the channels between walls 110 and then changes direction to pass from between the walls 110 to exit through openings 124. Since most installations will position the heat spreader plate as the lowermost, as determined by gravity, component of heat exchanger 100, the fluid outlet openings 124 will generally be positioned above the microchannels 103 such that fluid may flow from the channels upwardly through openings 124.

Fluid outlet openings 124 may be spaced from fluid inlet openings 114 so that fluid is forced to pass through at least a portion of the length of channels 103 where heat exchange occurs before exiting the microchannels. Generally, fluid outlet openings 124 may be spaced from known hot spot regions.

In the illustrated embodiment, where heat exchanger 100 is intended to be mounted with heat source 107 generally centrally positioned relative to the perimeter edges of heat spreader plate

102 and thereby the ends 103a of channels, openings 124 may be positioned at or adjacent channel ends 103a.

At least one opening 124 extends over any channel 103 through which it is desired that heat exchange fluid flows. Openings 124 may take various forms including, for example, various shapes, various widths, straight or curved edges (in plane or in section) to provide fluid flow features, open area, etc. as desired.

In use, heat generated by heat source 107 is conducted up through heat spreader plate 102 to surface 102a and walls 110. Heat exchanging fluid, as shown by arrows F, enters the fluid heat exchanger through port 111, passes into the header 112 and through opening 114. The heat exchanging fluid then passes down between walls 110 into channels 103, where the fluid accepts thermal energy from the walls 110 and surface 102a. The heat exchanging fluid, after passing through opening 114 passes down into the channels and then impinges against surface 102a to be diverted toward ends 103a of the channels toward outlet openings 124. Fluid passing through channels become heated, especially when passing over hot spots, such as in over central regions in the illustrated embodiment. Heated fluid passes out of openings 124, into header and thereafter through port 128.

The individual and relative positioning and sizing of openings 114 and 124 may allow fluid to circulate through the heat exchanging channels 103 while reducing the pressure drop generated in fluid passing through heat exchanger 100, when compared to other positionings and sizings. In the illustrated embodiment, for example, the central region 124a of openings 124 are scalloped to create an enlarged outlet region from the centrally located channels, relative to those on the edges. This shaping provides less resistance to flow through the more centrally located channels, again increasing flow past the central hot spot region on heat spreader plate 102.

A seal 130 separates fluid inlet passage 104 from fluid outlet passage 106 so that fluid must pass through the microporous channels 103 past heat spreader plate surface 102a.

With reference to Figures 4 and 5, a useful method for manufacturing a fluid heat exchanger is described. A heat spreader plate 202 may be provided which has heat conductive properties through its thickness at least about a central region thereof.

Microchannels may be formed on the surface of the heat spreader plate, as by adding walls or forming walls by building up or removing materials from the surface of the heat plate. In one embodiment, skiving is used to form walls 210.

A plate 240 may be installed over the walls 210 to close off the channels across the upper limits of walls 210. Plate 240 has portions removed to create openings 214 and 224 in the final heat exchanger. Tabs 242 may be used to assist with the positioning and installation of plate 240, wherein tabs 242 are bent down over the two outermost walls.

Seal 230 may be installed as a portion of plate 240 or separately.

After plate 240 and seal 230 are positioned, a top cap 244 can be installed over the assembly. Top cap 244 can include side walls that extend down to a position adjacent heat spreader plate.

The parts may be connected during assembly thereof or afterward by overall fusing techniques. In so doing, the parts are connected so that short circuiting from inlet passage to outlet passage is substantially avoided, setting up the fluid circuit as described herein above wherein the fluid flows from opening 214 to openings 224 through the channels defined between walls 210.

The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to those embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein, but is to be accorded the full scope consistent with the claims, wherein reference to an element in the singular, such as by use of the article "a" or "an" is not intended to mean "one and only one" unless specifically so stated, but rather "one or more". All structural and functional equivalents to the elements of the various embodiments described throughout the disclosure that are know or later come to be known to those of ordinary skill in the art are intended to be encompassed by the elements of the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 USC 112, sixth paragraph, unless the element is expressly recited using the phrase "means for" or "step for".

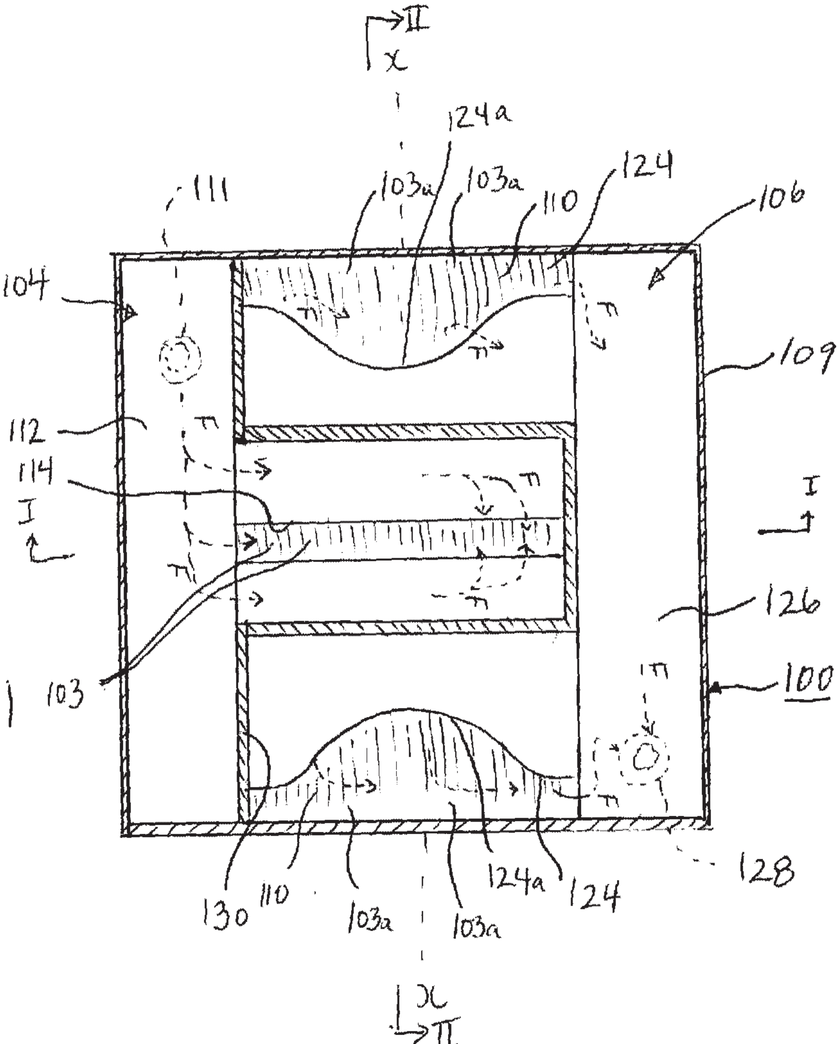

Figure 1

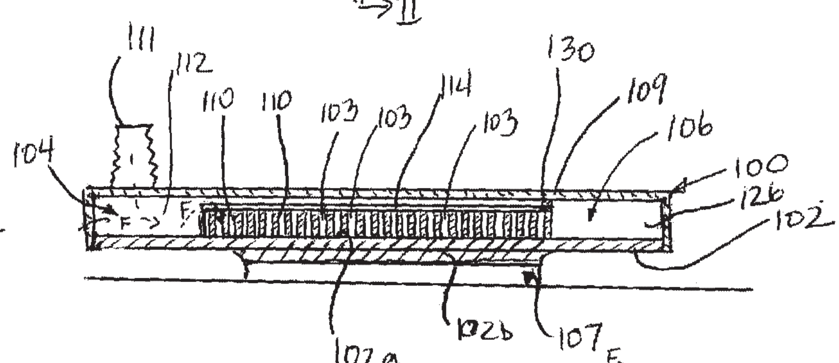

Figure 2

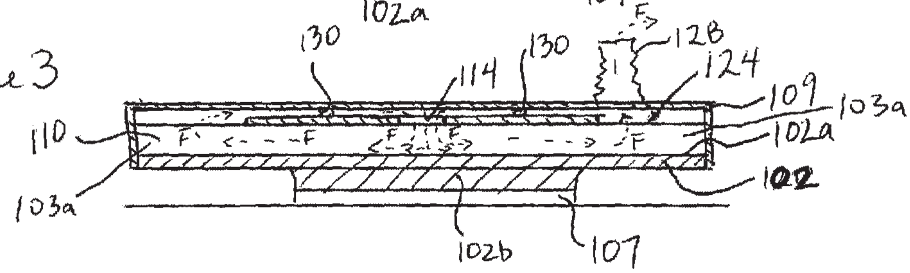

Figure 3

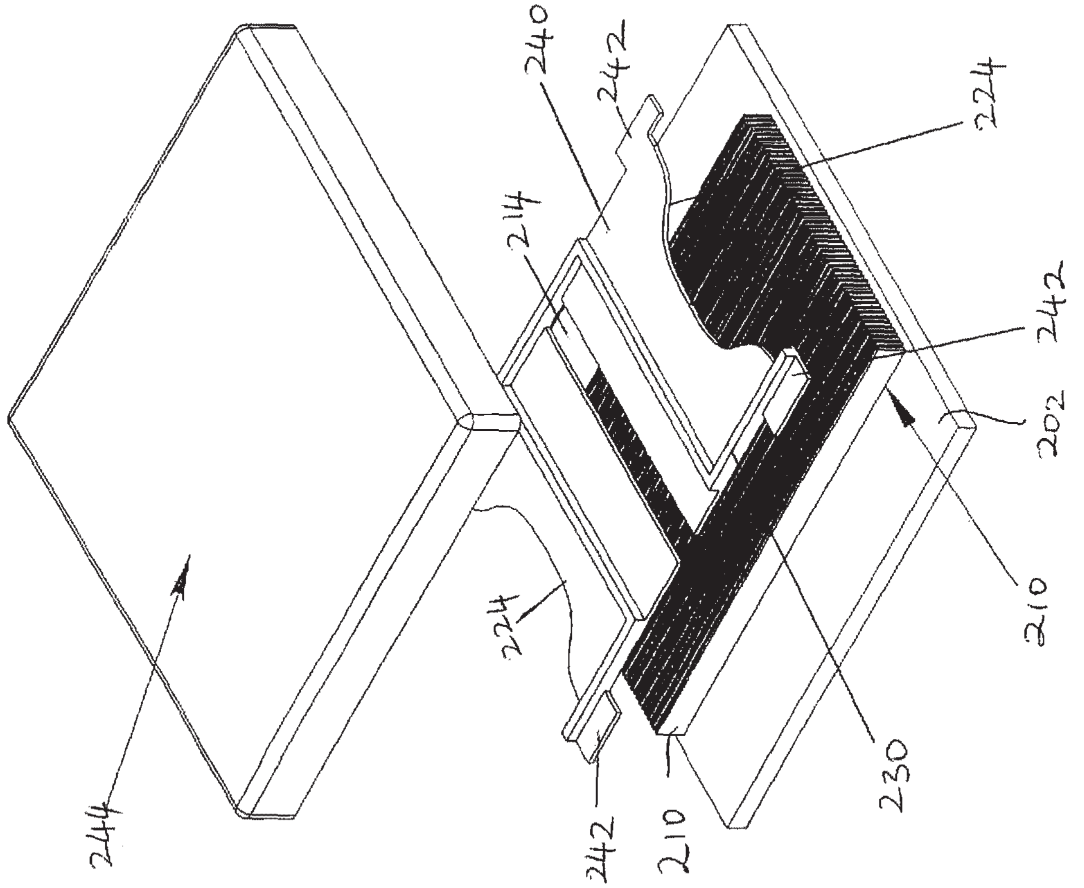

Figure 5

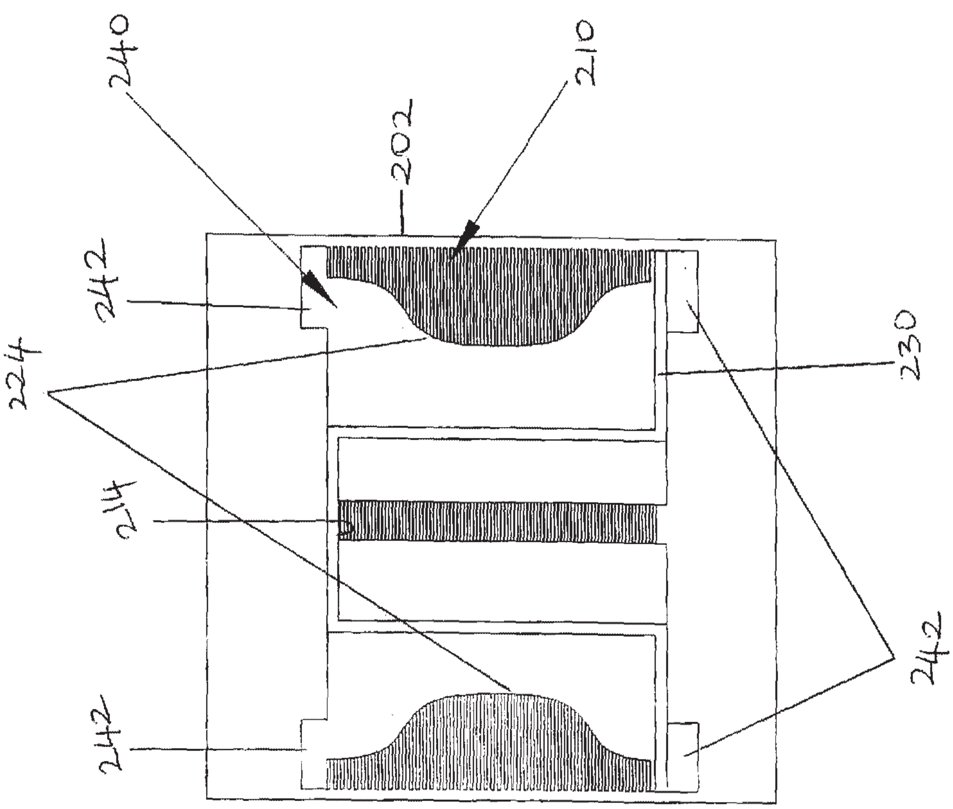

Figure 4

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	FLUID HEAT EXCHANGER
First Named Inventor/Applicant Name:	GEOFF SEAN LYON
Filer:	Roseann B. Caldwell/Ismat Rajan
Attorney Docket Number:	47621-65

Filed as Large Entity

Provisional Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Provisional application filing	1005	1	200	200
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**200**

Electronic Acknowledgement Receipt

EFS ID:	2067628
Application Number:	60954987
International Application Number:	
Confirmation Number:	3611
Title of Invention:	FLUID HEAT EXCHANGER
First Named Inventor/Applicant Name:	GEOFF SEAN LYON
Customer Number:	23971
Filer:	Roseann B. Caldwell/Ismat Rajan
Filer Authorized By:	Roseann B. Caldwell
Attorney Docket Number:	47621-65
Receipt Date:	09-AUG-2007
Filing Date:	
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Application Type:	Provisional

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Submitted with Payment	yes
Payment was successfully received in RAM	$200
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)

1	Application Data Sheet	47621-65-US_ADS_Form_SB_14.pdf	1028705 a14e70f9c49d9b161a6f3b837e33560f7e2e0bcd	no	4
Warnings:					
Information:					
2		47621-65-Specn.pdf	584627 fb536403de81654e27cbbeb4912937bd622709ac	yes	9
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	7	
	Drawings		8	9	
Warnings:					
Information:					
3	Fee Worksheet (PTO-06)	fee-info.pdf	8104 0952904c586c8418dec9a15d4168870daf20767d	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1621436		

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